ISS Has an Attitude!

Determining ISS Attitude at the ISS Window Observational Research Facility (WORF) using Landmarks

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Outline

- Concept
- Secondary School Activities
- Higher Education Activities

ISS Has an Attitude!

- Universities and secondary schools can help solve a real issue for remote sensing from the ISS WORF through hands-on engineering and activities
- Remote sensing technology is providing scientists with higher resolution, higher sensitivity sensors.
- Where is it pointing? - To take full advantage of these improved sensors, space platforms must provide commensurate improvements in attitude determination

ISS Has an Attitude!

- Experiments in the WORF will rely on accurate WORF attitude knowledge to determine their own attitude, to know what is in their image
- Two choices for finding WORF attitude:
  1. Translate ISS navigation base attitude to the WORF
  2. Provide WORF with sensors to allow it to determine its own attitude through direct measurements.
- This project takes the 2nd approach

Concept

- A WORF sensor (e.g. camera) will accurately measure the pointing vectors (in the WORF reference frame) to surveyed landmarks on earth
- A large number of landmarks will be required in order to provide continuous WORF attitude knowledge

Three Phases of Project

1. Proof of Concept
   - Carry out the exercise with a few schools using visible landmarks on earth and existing cameras on the ISS
2. Design & Development Phase
   - Design and develop several sensor systems to solve the problem
   - Trade study to identify sensors that best solve the problem
   - Involve more schools
3. Implementation Phase
   - Systemize the process and export it to schools nationwide (ultimately worldwide)
   - Integrate the process into the ISS as a standard service

Secondary School Activities

- Participate in constructing and maintaining surveyed landmarks
  - Prototype schools may help in developing basic accompanying curriculum
  - Fold participation into classrooms by addressing math and science education content standards
  - Team with Universities for developing algorithms and WORF sensor

Higher Education Activities

- Provide necessary algorithms to use landmarks for ISS attitude determination … develop them when necessary
- Partner with secondary schools to provide mentoring
- Conduct or assist with sensor trade study
- Develop feedback capability to participating ground stations for when their target is acquired

Needed Studies, Algorithms (Examples)

- Reference frame definitions
- Determine Vector from WORF to landmark
- Relate Pixels in Image Plane to WORF Reference Frame
- WORF Attitude Tracking Filter
- Calibration Techniques
- Target Detection / Recognition
- Automation

Reference Frame Definitions

- Take existing defined WORF reference frames (define them if they don't exist) and relate them to existing defined ISS reference frames
- Study how well ISS attitude measured at the navigation base can be translated to the WORF

Determine Vector from WORF to Landmark

- Given the ISS position and a landmark's position, determine the pointing vector in a standard reference frame
- Relate this vector to the WORF reference frame

Relate Pixels in Image Plane to WORF Reference Frame

- Each pixel in the sensor's image plane will correspond to a specific pointing vector in the WORF reference frame
- Develop algorithms to establish and calibrate this relationship

WORF Attitude Tracking Filter

- A Kalman filter will be needed to process the continuous input of new sensor data from the network of landmarks

Calibration Techniques

- As system accuracy improves, calibration techniques will become more difficult
- Associated algorithm development will be needed
- Techniques and algorithms must be designed to work within the time constraints of the ISS crew or autonomously

Target Detection / Recognition

- As the landmark network grows, the ability to detect and recognize targets will become critical
- Signal/image processing algorithms tailored to the selected sensors will need to be developed

Automation

- Techniques and algorithms will need to be optimized for automated operation as much as possible

OTHER IDEAS?